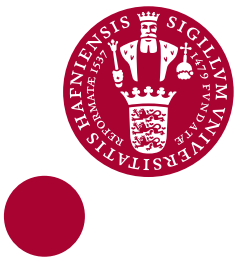

Warm temperature spells affect dormancy and cold hardening in Abies procera and A. nordmanniana

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Cold Hardiness and Morphological Characterization of Containerized Conifers Used as Live Christmas Trees

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Containerized conifers are increasingly marketed and used as live Christmas tree in the United States and around the World. The idea is to use the tree for the holidays and plant it into the landscape after the season. However, prolonged duration under warm winter indoor conditions can reduce the cold hardiness, resulting in shortening of the dormancy and resumption of growth. We examined cold hardiness and morphological characteristics of three species subjected to in home conditions for 10 and 20 days. Forty-five trees from three species (*Picea glauca, Abies balsamea,* and *Pseudotsuga menziesii)* raging from 90 to 150cm (3 to 5 feet in height) were dug at our farm at the Tree Research Center in East Lansing, Michigan and potted for the study. The trees were left outdoors for 45 days to allow them to go into full dormancy before the testing began. Cuttings were taken from the trees and subjected to an artificial freeze test (AFT) procedure. Physiological and morphological characteristics were evaluated through chlorophyll fluorescence, buds and needles condition, survival rate, and visual evaluation of the tree condition. Trees (all 3 species) subjected to the 10 days indoor treatments showed little to no bud damage when subjected to up to -21°C AFT, indicating that they were still cold hardy at that temperature. All three species displayed needle and bud damages at lower temperatures of -24 and -30°C. Trees subjected to the 20 day treatment showed considerable bud damage at -21°C and moderate damage at -18°C. Needle damage was apparent for *Picea glauca* at -21°C and *Pseudotsuga menziesii* showed damage at temperatures as high as -3°C. This result is consistent with the knowledge of Douglas fir as early bud breaker. Chlorophyll fluorescence measurements were good indicator of needle damages at low temperatures. Visual ratings were consistent with morphological changes observed in terms of damage to the buds and needles. Our results indicate that keeping containerized trees indoors for 10 days did not adversely affect the tree dormancy for the three species included in this study.

Warm temperature spells affect dormancy and cold hardening in *Abies procera* and *A. nordmanniana*

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Bud damages due to climate are frequent in cultivation of *Abies procera* Rehder in Denmark, less so in *A. nordmanniana* Spach. More extreme weather, such as spells of unseasonal warmth during winter, are expected with the pending climate change.

Cold hardiness and bud dormancy were tested during winter under varying acclimation regime (closed-top chambers) and experimental warm spells. *A. procera* revealed a deeper dormancy than *A. nordmanniana*. Acclimation regime did not strongly alter *average* dormancy, but seriously affected within-sample variation in dormancy release.

High acclimation temperatures resulted in less hardiness in *A. procera*. *A. procera* did not deharden in response to a warm spell in autumn, while *A. nordmanniana* dehardened considerably. Both species dehardened with warm spells in early spring, i.e. the natural dehardening was accellerated, but only *A. procera* could subsequently recover to approach the seasonal control. Responses differed with duration and timing of the warm spell. Warm spells

A

raised the frequency of "secondary dormancy" in in buds of *A. procera*, i.e., buds that remain apparently intact but with a delay in bud break.

For *A. procera*, fluctuating temperatures appeared particularly problematic, not only because of frost damages *per se*, but also because of reduced vitality, presumably because the adjustments (dehardening and recovery) are energy consuming. This explains the coastal climate preference of this species. Subcontinental cultivation requires sheltering, e.g by hedging, snow cover or topography.

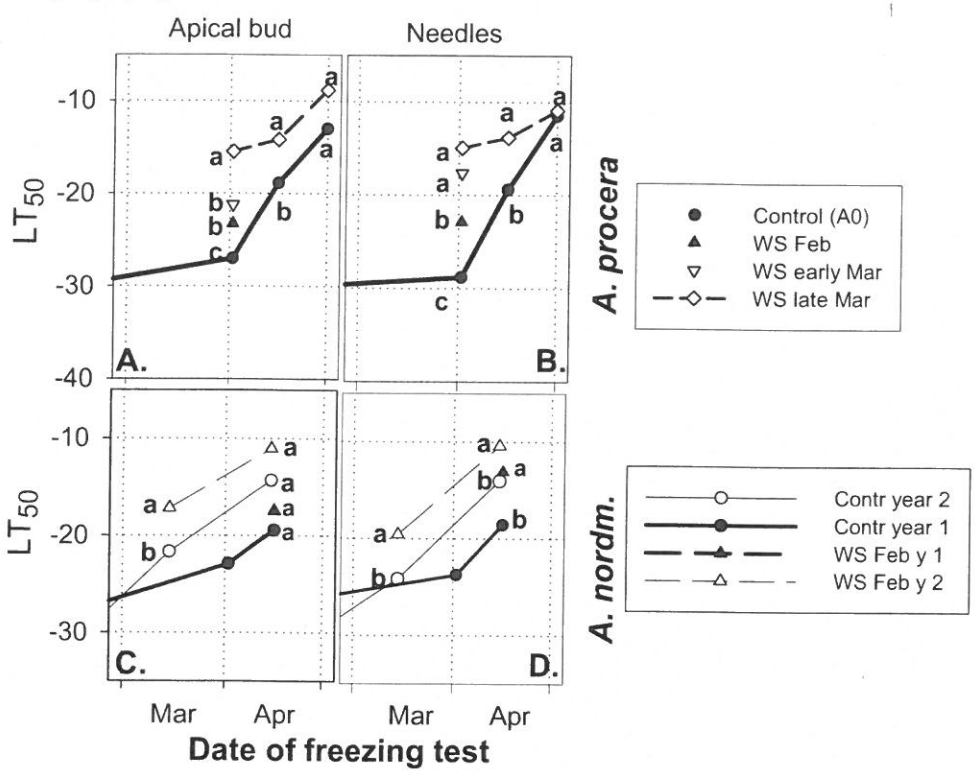

Figure 1. Dehardening in *A. procera* and *A. nordmanniana* in response to warm spells in later winter, parallel reactions in apical buds (left) and needles (right). Dehardening is expressed as an increase in the temperature that causes 50% of damage (LT_{50}). The more recent the warm spell at testing time, the stronger effect on LT_{50} (A, B). The late March treatment is seen to recover in subsequent tests (curve convergent to the control curve). In *A. nordmanniana*, however, dehardening after warm spell appears to be a permanent shift compared to the normal (control) spring dehardening process.

Hanne N. Rasmussen, Ph.D and D.Sc., is a plant biologist and senior scientist at Forest & Landscape Denmark, University of Copenhagen and has worked on species of *Abies*, mainly *A. nordmanniana*, for seven year. Main interest are growth regulation, hormonal relations in the tree crown, and whole plant physiology generally.

Christian Nørgaard Nielsen, D.Agr., is associate professor in forestry, also at Forest & Landscape Denmark. His research interests are within ecology and management of trees, particularly relating to structure and organization of the woody root system, biomass research, tree architecture, anchorage and physiological stability, tree longevity, and stress hardiness.